DOCUMENT RESUME

ED 280 257 EC 192 411

AUTHOR Vanderheiden, Gregg C.
TITLE White Paper: Access to Standard Computers, Software, and Information Systems by Persons with Disabilities. Revised, Version 2.0.
INSTITUTION Wisconsin Univ., Madison. Trace Center.
PUB DATE 27 Oct 85
NOTE 54p.; A product of the Trace Research and Development Center on Communication, Control, and Computer Access for Handicapped Individuals. For related documents, see EC 192 412-415.
AVAILABLE FROM Trace Research and Development Center, S-151 Waisman Center, 1500 Highland Ave., Madison, WI 53705 ($7.30).
PUB TYPE Viewpoints (120) -- Information Analyses (070)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Accessibility (for Disabled); *Computers; *Computer Software; *Disabilities; Display Systems; *Input Output Devices; *Microcomputers; Needs Assessment

ABSTRACT

The paper focuses on low cost and no cost methods to allow access and use (via specialized interface and display aids) by the disabled of standard unmodified computers and of microcomputer software systems becoming increasingly common in daily life. First, relevant characteristics of persons with movement, sensory, hearing, or cognitive disabilities are listed and related strategies for solution are described (e.g., use of alternate input approaches for the movement impaired, voice output for the visually impaired). The next section looks at ways existing computers could be made more accessible through such means as keyboard options, an alternate keyboard access feature in operating systems, visual redundancy of auditory information, and availability of an audio or headphone signal. Ways in which these access modifications can increase the usefulness of computers for the disabled (and market size for manufacturers) are pointed out. Possible ways that future computer accessibility for the disabled may evolve are noted and include increased availability of alternate interfaces, separation of programs from the input/output hardware, greater difficulty for the visually impaired as the visual complexity of displays increases, and increased use of voice-to-text translators by the hearing impaired. Attached are a position paper and a proceedings report pertaining to two computer industry/government meetings held February 1984 and October 1985 with the purpose of formally addressing the problem of computer accessibility for the handicapped. (DB)

WHITE PAPER: ACCESS TO STANDARD COMPUTERS, SOFTWARE, AND INFORMATION SYSTEMS BY PERSONS WITH DISABILITIES

Vanderheiden, G. C.

1984

Trace Center

Trace Research and Development Center
on Communication, Control, and Computer
Access for Handicapped Individuals
University of Wisconsin-Madison

Waisman Center/1500 Highland Avenue Madison, Wisconsin 53705-2280 (608)262-6966 TDD: (608)263-5408

VERSION 2.0

WHITE PAPER:
ACCESS TO STANDARD COMPUTERS, SOFTWARE, AND INFORMATION SYSTEMS BY PERSONS WITH DISABILITIES

Prepared for the Industrial Members
of the NIHR - White House Committee
for Equal Access to Standard Computers and Information Systems

Gregg Vanderheiden, Ph.D.
Trace Research & Development Center
Waisman Center
University of Wisconsin-Madison

Revised: October 27, 1985

TABLE OF CONTENTS

SIMPLIFY SOFTWARE DESIGNED FOR USE IN PUBLIC PLACES

HOW THESE ACCESS "MODIFICATIONS" INCREASE THE USEFULNESS (AND MARKET SIZE) FOR NON-DISABLED USERS (REGULAR MARKET OR MASS MARKET)

KEYBOARD OPTIONS

ALTERNATE "KEYBOARD" ACCESS FEATURE

ALTERNATE "SOURCE" CAPABILITY FOR ALL OTHER INPUT TECHNIQUES AS WELL (MOUSE, ETC.)

ALTERNATE VIDEO SIGNAL ALWAYS AVAILABLE

AUDIO OR HEADPHONE SIGNAL AVAILABLE

EXTERNAL AVAILABILITY OF INFORMATION SENT TO SCREEN

VISUAL REDUNDANCY OF AUDITORY INFORMATION

ALL INTER-PROGRAM DATA PATHS LEFT FULLY OPEN IN NEW OPERATING SYSTEMS AND ENVIRONMENTS

FUTURE POTENTIALS AND PROBLEMS

MOTOR IMPAIRMENTS

VISUAL IMPAIRMENTS

HEARING IMPAIRMENTS

OTHER NOTES

ATTACHMENTS

INTRODUCTION TO THE PROBLEM

THE COMPUTER IN SOCIETY – TODAY AND TOMORROW

Computers hold great potential for increasing the options, productivity, and participation by individuals with disabilities in industry and society. Computers also, however, have the potential for becoming the greatest new handicap disabled persons will ever face.

Many special computer programs have been written for individuals experiencing handicaps. These include programs to allow blind individuals to auditorially process text, translate text into Braille, and translate Braille back into text; programs to help deaf individuals learn sign language or better understand how to move their vocal mechanisms in speech (by displaying cut-away views of the mouth during speech); and programs to allow physically handicapped individuals to write, speak, and control devices in their environments. It is clear that with these programs, we can use the computer as a component or core of a special assistive device. In this role, the development of the computer has been nothing but a benefit to persons with disabilities.

There is a second role, however, that the computer will play in the lives of disabled persons. That is the same role as it plays and will play in everyone's life. Computers are becoming part of the curriculum in our educational system at an ever-increasing rate. Soon there will be computers in all classrooms, and they will be used as routinely as chalk and blackboards are today. Similarly, employers will be making more and more extensive use of computers in all aspects of employment. Even in daily life, we may soon be able to do most of our ordering and bill-paying using computers or data terminals from our homes. In all of these cases, however, the software is being written to be operated by individuals who have use of all senses and fingers. As such, they are for the most part unusable by many individuals who have physical disabilities.

TWO ROLES

Thus, we can see that we have two roles that computers will play in the lives of disabled persons: 1) as a special assistive device, running special software to meet particular needs of disabled persons, and 2) as one of a large number of different, standard computer systems running standard software that will be encountered in daily life. It is this second role that is the focus of this document. If we cannot identify or develop a mechanism that will allow a disabled person, with his or her special, adaptive equipment, to be able to access and use the standard, unmodified computers and software systems that he will encounter in daily life, then individuals with these disabilities will be unable to participate in any activities, educational

programs and employment settings that involve or require any use of or access to computer systems. Since we expect that this will include most regular educational and employment settings by 1990, this would be a very serious situation.

CURBCUTS AND COMPUTERS

The objective of this cooperative effort with industry is to identify low-cost and no-cost methods for providing access to standard computer hardware and software systems so that individuals with disabilities will be able to use their own specialized interface and display aids to access standard computers and standard software systems. Moreover, initiative is being taken at this time, and pursued with great earnest, so that these access strategies can be incorporated into standard computer architecture as early in the game as possible to avoid the high cost of retrofit later. The situation can in some ways be compared to curbcuts. We are currently in the process of moving toward an electronic information based society. In the process, electronic pathways are being laid throughout our society -- pathways that could tremendously increase the functional mobility, capability, and productivity of individuals with physical and sensory disabilities. All of these electronic information pathways, however, will be of little use if access to them is not available. Patching one or two access points on a couple of isolated computers (or just for the disabled user's personal computer) is not sufficient, any more than putting curbcuts or ramps on one or two sidewalks in a city (or just the sidewalks on the disabled user's block) would be sufficient. The objective of this cooperative effort is to begin talking about "computer curbcuts" before all of the "sidewalks" have been laid and the curbs poured.

These access strategies under development bear a second interesting similarity to curbcuts: that is, they are general-purpose open access strategies that are likely to be of as much value to non-disabled individuals as to disabled individuals. It has been estimated that for every single disabled person who uses a curbcut, there are ten able-bodied cola delivery persons, children (or adults) on bicycles, or elderly citizens with shopping carts who use the same curbcut. Similarly, the open access strategies necessary to allow persons with disabilities to input to and receive information from standard computer and information processing systems will be of benefit to a large portion of the non-disabled market as well.

TYPES OF DISABILITIES AND THEIR CHARACTERISTICS

There are many ways of grouping individuals with disabilities. The following categorization is used in this report to facilitate discussion of the ramifications of computer/software design and solution strategies.

I. Movement Disabilities

A. Restricted but normal motor (i.e., muscle) control

Neurological birth defects

Spinal cord injury

B. Weak or limited range of movement

Spinal cord injury

Brain trauma

ALS (Amyotrophic lateral sclerosis (Lou Gerhig's disease)

MS (Multiple sclerosis)

MD (Muscular dystrophy)

Polio

Orthopedic disorders

C. Interference with motor control

II. Sensory Disabilities

A. Visual impairments

Acuity (low vision)

Processing (perception)

Color blindness

Blindness

B. Hearing Impairments

Acuity (hearing loss)

Processing

Deafness

III. Cognitive Disabilities

A. Learning disabilities

B. Retardation

C. Integration

D. Processing (dyslexia)

MOVEMENT DISABILITIES

For individuals with movement disabilities, it is the input mechanisms (e.g., keyboards, mice, etc.) to the computer that present the greatest problems. Also involved, but generally of less concern, are adjustments or other controls that may be on the computers or displays. In addition to difficulties in using the computer itself, individuals with movement disabilities may also have difficulty in manipulating many computer-related materials such as disks, printouts, etc.

Individuals with weakness or mild to moderate movement disorders may be unable to use standard keyboards, but are often able to use adapted or miniature keyboards. Individuals with high spinal cord injuries (no control below the neck), as well as individuals with extreme interference or weakness of their motor control systems, are often unable to use a keyboard of any kind. They are, however, able to use other special adaptive aids that could be used instead of the keyboard.

These alternate input mechanisms include sip-and-puff Morse code, voice recognition, scanning techniques requiring only the ability to activate a single switch, and eye-gaze keyboards that "type" when the individual simply looks at the "keys." These interfaces exist commercially, but there is currently no way to allow them to be used instead of the standard keyboards on unmodified computers running standard software. (Computers can be individually modified with keyboard emulating interfaces to allow their use – see below.)

As newer interface technologies appear (mice, touch screens, lightpens, touch pads), these problems take on new dimensions. Alternate access mechanisms need to be developed for all of these input approaches if individuals are to have access to standard educational, recreational, and productivity software.

SENSORY DISABILITIES

While physically disabled individuals have difficulties inputting to and controlling computers and software, the sensorially disabled experience their primary difficulties in getting information from the computer.

VISUALLY IMPAIRED

Visual impairments fall into four general categories:

1) visual acuity
2) visual perception
3) color blindness
4) blindness

People with VISUAL ACUITY impairments have difficulty seeing at a distance or close up, or focusing the image. These individuals have the greatest difficulty with the displays on computers (CRTs, LCDs, etc.). The small lettering on some of the newer keyboards, however, also poses a problem for individuals with limited visual acuity. With the aging of the computer-using population, problems in visual access will be of increasing concern. Availability of optional large-screen displays helps somewhat with personally-owned systems, but does little for the larger problem of access to computers in public, educational, and employment settings.

VISUAL PERCEPTION PROBLEMS are the problems faced by individuals whose eyes focus well, but who have visual processing difficulties that make it difficult or impossible to handle printed information or complex displays. This is more of a software design issue than a hardware or system access issue. Simpler, larger displays may help on systems to be used for the public, as would some of the solution strategies for totally blind individuals.

COLOR BLINDNESS will pose increasing problems as color displays are increasingly used. This, too, is largely a software question, although alternate display options could be of benefit. The problem is best addressed by careful selection of colors which appear different in shade to color blind individuals, or through redundant cues.

BLINDNESS, of course, presents severe problems for using standard software, due to the high reliance of the software on the visual display of information. Alternate display approaches (voice and Braille, most notably) exist, but usually cannot be used to access the screen images produced by standard software without modifying the operating system or the computer itself. Manuals and information on how to use these systems and software are usually not available in a form that is usable by blind individuals (e.g., in Braille or on disk).

HEARING IMPAIRMENTS

Individuals with hearing impairments are not currently at a great disadvantage when trying to use standard software packages. Some warnings that appear <u>only</u> as sounds or tones are a problem. Warnings that are both visual and auditory generally are not a problem -- especially if the visual warning is difficult to miss. Some newer programs that use speech as output or to guide or assist the user do pose a significant barrier when the information is not also provided in visual form (e.g., on the screen). Public access computer system developers (information systems, etc.) may want to note that English is a second language to many deaf individuals who communicate in American Sign Language (which is a totally different language from English).

COGNITIVE DISABILITIES

The problems of persons with disabilities in this area generally affect the design of software programs, rather than the hardware or operating system architecture. Specific learning disabilities, memory problems, and retardation are examples of disabilities from this category. Each of these disability areas, however, is very distinct from the others, and poses different constraints. Public access systems in particular may want to consider the complexity of keyboards and visual displays, memory requirements (on the part of the user), and the cognitive demands of their programs and systems. Clear, simple, step-by-step directions and documentation are important, as is the lack of clutter on screens. All of these measures also increase the ease of use of systems by the elderly and by the general public.

SOLUTION STRATEGIES NOW IN USE (OR WHICH HAVE BEEN DEVELOPED TO DATE)

There are currently a number of modifications and retrofit solutions that have been made to existing hardware and software systems to allow access by disabled persons. There are also a number of special interfaces that have been developed either for general communication purposes or specifically for accessing computers which can be used as alternate input and output systems for disabled persons. This section discusses some of the existing aids, and how they can be used to access computers and standard software. Also discussed are limitations of these approaches.

MOVEMENT DISABILITIES

SHIFT, CONTROL, and ALTERNATE KEYS

Many individuals are able to use a standard keyboard but do so with a single finger, a mouthstick, or a head-mounted stick. In all of these cases, the individual is able to hold down only a single key at a time. Many computer operations, however, require that individuals hold down two or more keys at the same time. The SHIFT, CONTROL, and ALTERNATE keys are the most common examples of this, although other key combinations are used. To overcome this problem, a variety of mechanisms have been developed to hold down one key while the individual presses another. Some of these mechanisms take the form of a weight that can be tipped onto the key to hold it down. Others are bi-stable "teeter-totter"-like latches. One end of such a latch is positioned over the key (e.g., the SHIFT key). Pressing on that end causes it to snap down and hold the (SHIFT) key while the user types other keys. Pressing the other end of the teeter-totter latch releases the key. While this approach works well, it is inconvenient on computers that are also used by non-disabled users, since the latches must somehow be attached to the computer, and are in the way when the computer is used by non-disabled users. Another problem with the latch approach is that on many keyboards the keys that must be held down are in the middle of the keyboard, where it is difficult to attach a latching mechanism.

A second approach to solving this problem involves creating software modifications to the operating systems. This approach does not work with software that does not go through the operating system for its "keystrokes." Also, each time the operating system is revised, the disabled individual must have a new "fix" prepared. Finally, as we move further into the information society, many disabled individuals will deal with a number of different computers throughout the day. For this patching strategy to work, a "fix" must be written, paid for, and installed on all of the computers with which the individual must deal. This is usually not possible, physically or economically. Modification to the operating system is also not permitted in many locations where an individual may need to use a computer.

REPEAT KEYS

Many of the newer computers have automatic repeat keys on their keyboards. While this may assist normal typists, a number of individuals with more severe handicaps have difficulty with the spontaneous generation of extra characters due to the repeating feature. At the present time, the only way to fix this problem on most computers is to make modifications to the operating system. For other computers, however, the modifications must be done as "fixes," and suffer all of the problems of software fixes to the operating system that were discussed above.

ALTERNATE INPUT APPROACHES

A wide variety of alternate input approaches have been developed, originally for specialized communication and writing systems for disabled individuals. These specialized input approaches allow individuals using a single switch, sip-and-puff control, eye gaze control, etc., to use special communication aids. Some examples of these specialized interface aids are listed here.

> The **AUTOCOM** is a special communication aid that can interpret very erratic pointing motions on a matrix of 1" squares. The aid has a built-in display and printer, as well as an RS232 output port.
>
> The **EXPRESS III** is a special communication aid with several special input modes. One of the modes allows the individual to select letters and words from a 128-square panel using a single switch. Rows of selections are illuminated, one row at a time, until the individual hits the switch. The individual items in that row are then illuminated one at a time until the individual hits the switch a second time. The item selected in this fashion is then either put on the display, printed, spoken, or sent out along the serial output port. Another mode of operation of this aid allows the individual to point directly to the items on the display panel using a special optical pointer mounted on the individual's head.
>
> The **EYETYPER** is a special interface keyboard that operates with eyegaze. The aid consists of a 12" x 5" matrix of 2" squares or "keys," and a special camera [illegible]e processor. As the individual looks at the keys, the image pr[illegible]n tell which key the individual is selecting. The selected keys can then be shown on the aid's display or sent to another device.
>
> **MORSE CODE:** Several devices are available that allow individuals using two switches to send Morse code. Individuals with a high spinal cord injury can use quick sip-and-puff movements with their mouth to "type" using Morse code.
>
> **LIGHTBEAM KEYBOARDS:** Several special "keyboards" are available that can be operated by simply pointing to the "keys" with a beam of light. Individuals with spinal cord injury, weakness, or

progressive diseases often use lightbeams attached to their heads to operate these keyboards.

These and other interface techniques and aids can be used with computers. Unfortunately, the output of these aids does not look like the output of the standard keyboards. As a result, these interfaces cannot be directly substituted for the standard keyboards on computers. They could be connected to the serial ports of the computers, and used with special software expecting the input to come in via the serial port. In order for these interfaces to be usable with standard software, however, some mechanism must be provided to allow the output from the special aid to look like it is coming from the standard keyboard. Keyboard emulating interfaces are one strategy for accomplishing this.

KEYBOARD EMULATING INTERFACES

In order to allow special interface devices and communication aids to be used in place of the standard computer keyboards, small KEYBOARD EMULATING INTERFACE MODULES have been developed. These modules are capable of exactly imitating the signals that are sent out by a particular keyboard (e.g., the IBM PC keyboard, or the Apple IIe keyboard). These modules are designed to accept the output of the special interfaces and communication aids and convert the signals into precisely the same electrical signals that the particular computer keyboard would generate. In this manner, an alternate keyboard with these special interfaces can be used instead of a computer's normal keyboard, since the computer is unable to tell that the keystrokes are not coming from its normal keyboard. This approach allows the disabled individual to use all of the standard keyboard-based software written for the computer without requiring any modifications to it. Because the computer cannot "see" that the keystrokes are not coming from its normal keyboard, this technique is referred to as a transparent access technique. In order to allow other non-disabled individuals to continue to use the standard keyboard, all of the keyboard emulating interfaces also allow the normal keyboard to be plugged into them. Thus, all "keystrokes" received from either the normal keyboard or from the disabled person's special "keyboard" are passed on to the computer as standard keyboard keystrokes.

Although this approach does provide full transparent access to keyboard-based software, it has several problem and limitations:

1) Individual keyboard emulating interfaces run about $400 each, and are usually specific to a single computer model.

2) Since any disabled individual is likely to run into multiple computers, separate keyboard emulating interfaces must be secured for each computer.

3) Each computer with a different keyboard requires a different keyboard emulating interface. Even different models within the same computer line often have different keyboards, and require different emulating interfaces. The Apple II+ and the Apple IIe, for example, each require different emulating interfaces, as do each of the IBM PC, the PC jr, and PC-AT computers.

4) As new computers are announced, keyboard emulating interfaces must be designed and made commercially available. This is a difficult and expensive process. As a result, only the most popular models of the most popular computers have keyboard emulating interfaces available for them.

5) Keyboard emulating interfaces are not currently available on all public access computers.

6) Keyboard emulating interfaces often require custom installation. Computers appearing in educational, recreational, employment, and public areas (e.g., libraries) are often under the charge of individuals not familiar with computers, who are hesitant to include "non-standard adaptations." As a result, computers that disabled individuals will be encountering in various areas will usually not include keyboard emulating interfaces unless they were a standard feature of the operating system.

As computers become an integral part of more and more activities of daily living, the disabled individual will run into more different types of computers in different environments each day. The cost for him or her to outfit each computer with a separate keyboard emulating interface would be prohibitive. In addition, many of the computer systems either would not have keyboard emulating interfaces available for them, or would not allow the disabled individual to install such non-standard devices.

OTHER INPUT TECHNIQUES

In addition to keyboards, other input techniques are being implemented on a widespread basis. Perhaps the most common at the present time is the mouse. Although software packages using the mouse often allow some of the commands to be done from the keyboard, there are some systems that are not usable if the individual is unable to use a mouse. To circumvent this problem, several "mouse substitutes" have been developed. In one case, a long-range lightpen (one that can be used up to 3' away from the screen) has been programmed to emulate the signals of the Macintosh mouse. An individual can now cause the "mouse pointer" on the screen to move about by simply pointing with his head at the screen. In another case, the tipping of the head left, right, forward, or backward is sensed by a special device that emulates the signals put out by the Macintosh mouse, as does an ultrasonic head operated mouse. Also under development is a keyboard emulating interface with a mouse emulating interface included. This unit allows signals from special communication aids and

alternate input devices (see above) to be used instead of the Macintosh's keyboard and mouse.

In all of these cases, however, special "mouse emulating" circuitry and adaptations needed to be developed in order to let non-mouse users access the Macintosh. This circuitry must be redesigned and redisseminated for each different computer and/or mouse system that comes out.

MANIPULATION OF COMPUTER MATERIALS

As discussed previously, in addition to the need for alternate input devices physically handicapped individuals also often have difficulty handling computer materials such as disks and printouts. Special disk loading racks have been developed to held disabled individuals line up and insert disks into their drives. There are problems, however, with those disk drives that have latches which are difficult to use unless one has good manipulative capabilities. Also, the location of the disk drives can create problems. The Apple IIc, for example, has a latching mechanism which is particularly easy to use. Unfortunately, the disk drive is mounted on the side of the computer, which makes loading disks difficult for disabled individuals.

For the more severely motor impaired individuals, mechanical disk loaders have been developed. However, these units are quite expensive, and so far have had low reliability.

The rapidly dropping cost of hard disks has made their use a particularly valuable approach for disabled individuals. Software that is copy-protected, however, limits the ability of disabled individuals to use a hard disk to reduce disk handling requirements. Programs such as Microsoft's Word, which allows a single copy to hard disk, are good examples of a compromise that provides reasonable program security while still allowing the transfer of the program to a hard disk.

SENSORY IMPAIRMENTS – VISUAL

The principle problem faced by visually impaired individuals is the output display. Other problems include the use of sight-based input systems (mice and other variable-origin or variable-reference systems), computer printouts, and documentation.

The current solution strategies include:

1) expanded displays
2) Braille printouts and displays
3) voice output
4) avoidance of mouse-based and other inaccessible programs

EXPANDED DISPLAYS

For individuals with visual acuity problems (low vision), expanded displays are available. For individuals with only minor vision problems, the use of larger monitors (which results in larger letters) may be sufficient. For individuals with more severe

vision problems, specially developed screen displays are available for many popular computers (Apple, IBM, Tandy) that allow the user to zoom in on a special screen. Systems are available that can zoom in so far that one character will fill the screen. Some of these systems allow the screen to be split between the video display of the computer screen and a second display taken from a camera aimed at printed material (books, etc.) that the individual might be using. These expanded "zoom" display systems are accomplished by patching into the operating systems, or through direct access to the screen memories in the various computers. As such, they must be custom developed for each computer and operating system. Although they do provide a solution approach for personal systems, they would not be a viable personal solution for accessing public computer systems in their current form. They also limit the choice of computers which an individual with low vision could purchase and use, as they are only available for the most popular models of the most popular computers, and are not available for any computers until some time after their announcement.

BRAILLE PRINTOUTS AND DISPLAYS

Braille displays come in two forms: Braille printers and dynamic Braille displays.

Braille printers are available that can provide embossed Braille printouts from standard computer terminals. The cost of these Braille printers is high ($15,000; prints 100 characters/second), although a lower cost modification to a hand Brailler is available for $3,000 (12 characters/second). Braille printout can solve some of the problems regarding access to printed output. It is not, however, suitable for replacing the CRT display, any more than a standard printer could be used instead of a CRT for sighted individuals.

To help meet the need for fast, temporary display of Braille information, dynamic Braille displays have been developed. These have small pins that can be raised and lowered electrically. There are currently several terminals that have between 20 and 40 Braille cells in a line. Controls are used to move this "line" up and down a virtual screen image. Work is also underway on a large "full page" Braille display that would consist of 40 x 16 Braille cells or "characters." It may also be possible to use this panel for limited display of graphic information in tactile form. In its graphic mode, the resolution of this display would be 64 x 128 pins or pixels for a 10" by 7" display (which can be stacked at production time).

At the present time, only a small percentage of blind individuals read Braille. In addition, many blind individuals do not have sufficient sensation in their fingers to learn Braille. For those who know and use Braille, this approach can be a very powerful and effective approach for text information.

VOICE OUTPUT

To facilitate access to computer systems by a larger population, including those not familiar with Braille, voice output approaches have been used. With these

systems, an individual is able to move a "speaking" or "reading" cursor around the screen, and have it vocally read back the contents of the screen to the user. The cursor can be moved around in word or letter mode, and can read forward or backward at varying speeds. Current systems use cursor control commands from a keypad or two slide controls. A new "hapti-vocal" technique has also been proposed that would allow the individual to directly access the contents of the screen. With this technique, a small pad which represents the screen is located next to the user's keyboard. Whenever the individual touches the pad, the contents of the screen which correspond to the point on the pad which the individual touched would be spoken. The individual can "read" the screen by simply moving his hand across the pad, or by touching the pad with two fingers and spreading them to control the rate of reading. Both of these techniques also have an "echo" mode that allows the information to be read back to the individual as he is typing it, if this is desired.

AVOIDANCE OF MOUSE-BASED AND OTHER INACCESSIBLE PROGRAMS

At the present time, there is no good solution for blind individuals to the problem posed by mouse-based programs, or other programs which do not have fixed or tactilely referenced input techniques. At the present time, many of these programs have a "non-mouse" operating mode that permits their use. Many other programs and systems, however, are only partially accessible from the keyboard, and require the use of the mouse for at least some of their operation. Some variant on the hapti-vocal approach might be possible here. At the present time, however, good solution strategies have not been developed that would allow blind individuals to access mouse-based systems.

PROBLEMS AND LIMITATIONS OF THE ABOVE SOLUTION STRATEGIES

All of the solution strategies discussed involve access to the screen information. This must be done either through a modification or patch to the operating system, or direct access to the screen memory. In either case, it involves some physical or software modification or addition to the system. As such, it could not be used by disabled individuals to access screen information on the arbitrary computers they will encounter in their environments. These strategies could be used as mechanisms for accessing their own personal computers. Their choice of personal computer, however, will be limited to the one or two brands for which these software patches or memory access modifications are available. If access to this information could be provided as a standard feature on computers, many of these limitations would be removed.

Some newer proposed approaches seek to circumvent this access problem by direct interpretation of the video image. Such a system would tap the video signal being sent to the display monitor, and reconstruct the image in its own memory. The special device would then do character recognition and video interpretation on this video image and translate it into braille or voice output. Such a system would allow blind

individuals to use any computer for which they had access to the video signal. Some integrated computers, such as the Macintosh, however, do not currently provide an external video signal. In addition, newer systems based on liquid crystal displays do not generate a video signal; thus, none is available from many of these computers.

In addition to difficulties in getting access to the screen image in digital form, the above solution strategies can also have difficulties with the actual contents on the screen. Windows and graphics are a problem. Icons are somewhat of a problem, but are more manageable than general bit-mapped graphic displays and complex window graphics.

Graphic tactile displays can provide a partial solution to this problem. The very low resolution (64 x 128 pins or pixels) of these displays, however, is insufficient to represent the detailed graphic images of current systems (currently 640 x 400, with 1024 x 1024 coming soon). As the resolution of the displays increases, this problem will only get worse. In addition, the tactile displays are unable to represent color, which is being used increasingly on these displays. Finally, the cost of these displays is very high, and the cost of higher-resolution displays would be prohibitive. Some of these problems can be circumvented by using the graphic displays in a "zoom" mode, where the tactile display represents only a portion of the screen; a small movable window onto the screen, as it were. Another approach would be to have a small hand-held device the size of a gum or cigarette package, with movable pins under the user's fingers. As the device was moved around on a table representing the screen, a tactile image of the corresponding portion of the screen would be presented to the finger tips. Such a device might be termed a dynamic virtual haptic-tactile display.

The advent of a virtual device interface standard between graphics programs and the operating system would assist in all of the above solution strategies. The fact that such an interface would allow standard programs to be used with variable resolution displays would greatly facilitate the use of standard programs with the low resolution tactile displays. They could be used in full screen mode to get a general layout for the screen, and then zoomed into particular portions to provide higher resolution representations. Such interfaces between the program and the display systems could also provide information to other special devices for the blind, which could then reinterpret the information and provide it to the blind person in a form more appropriate to him (Braille, voice, etc.). This will be particularly important as displays become more complex and are presented in fonts. In order for this interface standard to be of any value to blind individuals, however, the information sent out from the program to the operating system will also need to be made available outside of the computer via some output port.

SENSORY IMPAIRMENTS -- HEARING

For hearing impaired individuals, access to standard software is not currently a large problem. The auditory information from computers is mostly in the form of

clicks or tones. The largest problem for hearing impaired individuals is the potential problem what will come with more complex auditory signals and speech output from standard programs. Solution strategies for this area include:

AMPLIFIER: For some individuals, the use of amplifier headphones may be all that is required. This approach can provide a loud, clear signal without also amplifying background noises. This is a good technique for computers that have a headphone or external audio jack. This approach is not viable on computers that do not have built-in headphone jacks. Such jacks could be added on personal systems, but even minor rewiring of general public computer systems is rarely allowed.

SOUND DETECTOR: For individuals who are deaf, a small sound detector that converts clicks and tones into flashes of light can cover many of the "warning tones" produced by current programs. Since such a device can be made quite small and portable, it could be easily carried by the deaf individual and placed in front of the speaker of any computer he would encounter. This technique would <u>not</u> be able to easily differentiate between the different sounds that a system might generate. It also would not help with programs that generate speech.

CONCURRENT DISPLAY OF INFORMATION ON SCREEN: When beeps are accompanied by a flash on the screen, or spoken output is also displayed in visual form on the screen, they pose little or no barrier for hearing impaired individuals. Simple, straight-forward messages are best, however, since English is the second language for many deaf individuals (sign language being the primary language).

ALTERNATE DISPLAYS OF INFORMATION: For programs that do not provide display of the spoken information on the screen, an alternate display could be used for visual display of the information. Such an alternate display could be connected to the computer using a standard output port. This would, however, require that the program or the operating system provide this information to the output port.

<u>COGNITIVE IMPAIRMENTS</u>

This area is very broad, and difficult to discuss or approach concretely. Often, the question is not access to standard software, but rather designing standard software to be usable by individuals with cognitive or sensory processing disabilities. This area is of primary concern for software or information systems to be used in public locations or activities.

Some of the problems can, however, be partially addressed by the same access strategies discussed above. A person who can see clearly but who cannot process printed information (e.g., a person with severe dyslexia) may be able to [illegible] systems with little difficulty if he could access the information auditorially, as a [illegible]nd individual might. Thus, the access ports provided for blind persons may [illegible] be of value to such individuals. Similarly, individuals with short term memory problems may find that the alternate visual display provided for deaf individuals would be

easier to interpret, or may be necessary in order to refresh their memory as they perform a task guided by computer-spoken instruction.

HOW EXISTING COMPUTERS COULD HAVE BEEN MADE MORE ACCESSIBLE

The comments and suggestions in this section are made with an understanding of the complexity and competitiveness of the designing and marketing of microcomputer systems. Most of the suggestions are low-cost or no-cost in nature, although there may be initial costs to incorporate them into standard design procedures. It should be noted that all of these proposed modifications increase the flexibility of the systems, and their utility to non-disabled individuals (regular market) as well. Further discussion of the benefits to the regular market is presented in the next section.

The following recommended modifications are being suggested after consultation with researchers, consumers, and several manufacturers. It is expected that this set of modifications can be refined considerably through more extensive cooperative work with industry. In addition, solution strategies must still be explored for future interface and display technologies.

KEYBOARD OPTIONS

An option in the keyboard routine or driver could allow the individual to adjust or defeat the KEY REPEAT FEATURE to avoid multiple keystrokes by individuals with motor impairments.

For the SHIFT, CONTROL, and ALT keys, a hold/lock feature could be added to allow use of the keyboard by individuals who can use only one hand or one stylus. When this option was enabled, depressing the SHIFT key once would cause the next character to be shifted. The system would then revert to its unshifted state. Depressing the SHIFT key twice in a row could cause the system to lock into shifted mode until the SHIFT key was depressed a third time. This same HOLD/LOCK feature would be provided for other keys on the keyboard as well. If programs appear on the market that require simultaneous depression of arbitrary keys on the keyboard, then it may be appropriate (and necessary) to allow the user to specify any keys on the keyboard as having this feature. This feature would automatically turn itself off any time two non-adjacent keys were depressed simultaneously. In this way, the feature would automatically deactivate if an able-bodied user came across a computer where a disabled user had forgotten to turn off the feature before leaving.

ALTERNATE "KEYBOARD" ACCESS FEATURE

This feature would modify the current operating systems to that the operating system would check both the keyboard and a designated serial input port whenever a program made a request for keyboard input. "Keystrokes" received from either source would be treated identically. Thus, the operating system would make no distinction between input from the standard keyboard or from an alternate keyboard, and the

program would be unable to tell that the "keystrokes" from the alternate "keyboard" did not come from the standard keyboard.

Since most keyboards have many more keys th·· can be supported by 7-bit ASCII, a special filter would be applied to all data coming in from the alternate keyboard input serial port. This filter would serve three purposes: 1) it would allow multiple keys to be "held down simultaneously;" 2) it would allow the user to "type" keys that are not represented by the ASCII code; and 3) it would allow the "time" the key is held to be transmitted (a requirement for some programs). A special standard has been developed to accomplish this. The standard uses 7-bit ASCII only as the input stream to the filter, and uses escape sequences for non-ASCII keys, the escape key, and keys that are to be held down simultaneously.

For systems that work on an interrupt-based keyboard, the serial port could cause the same interrupt as the keyboard. The operating system would then look at both the keyboard and the alternate input port for "keystrokes." If an "alternate input" vector were used, it would be possible to daisy chain any number of alternate inputs using different input interfaces. Whenever a new alternate keyboard routine was loaded, it would capture the address of the vector on the stack, and substitute its vector. When its access routine was completed, it would then pass control on to the other input drivers. However, <u>the keyboard and the handicapped keyboard emulating interface input drivers should be standard in all copies of the operating system</u>, so that they will be present in the operating systems of any computers wherever they appear (school, work, bank, street corners, etc.). This is important since in most cases the user will not have permission or the freedom to load the alternate keyboard driver into these public access computers. A single "alternate keyboard" input standard has been developed (termed the "Keyboard Emulating Interface Standard") and could be used by all disabled individuals.

It has also been suggested that a separate "alternate access" connector/port might be included in future computer design. This would be particularly reasonable if widespread use of this were predicted by the regular market. To avoid the higher costs of the serial connectors, a low-cost infra-red link mounted directly on the mother board was also mentioned.

<u>ALTERNATE "SOURCE" CAPABILITY FOR ALL OTHER INPUT TECHNIQUES AS WELL (MOUSE, ETC.)</u>

As new input interfaces are developed, some alternate source mechanism similar to the keyboard emulating interface function should be provided to allow use of the systems by individuals who cannot use the particular input system (e.g., mouse) provided.

ALTERNATE VIDEO SIGNAL ALWAYS AVAILABLE

In order to allow special display amplifiers and interpreters to easily tap into the video image, a video connector should be provided whenever a video signal is available.

AUDIO OR HEADPHONE SIGNAL AVAILABLE

An audio or headphone jack on the computer would facilitate the use of headphones and amplifiers for hearing impaired individuals.

EXTERNAL AVAILABILITY OF INFORMATION SENT TO SCREEN

Any information sent to the screen could also be sent to a serial (or other) port in some standardized format (on request or continuously). This could be the same serial port as used for the keyboard emulating interface input. This information could then be used for interpretation by a special personal "display" which the disabled individuals would have with them and could connect to the port. This will be especially valuable when new information display communication standards come out, such as the VDI. Any information sent to the operating system could also be sent to an output port so that it was available to other standard and special display devices for disabled individuals.

VISUAL REDUNDANCY OF AUDITORY INFORMATION

All information that is available as sounds or speech could also be displayed on the screen. Since this will not always be practical, the information could also be sent out on an access port, so that it could be displayed on a visual display that the deaf individual would carry. The access port could be the same one as is used for the keyboard emulating interface and blind interface.

ALL INTER-PROGRAM DATA PATHS LEFT FULLY OPEN IN NEW OPERATING SYSTEMS AND ENVIRONMENTS

When new operating systems are created that allow programs to pass data back and forth as "keystrokes," care should be taken so that all "keystrokes" that are possible from the keyboard be producible and passable from one program to another. This would allow the use of a "special keyboard" program to control the rest of the computer's operation. All key combination that can come from the keyboard, however, would need to be supported, including "RESET." This would allow a physically handicapped person to use a special program to act as an alternate keyboard routine to another program (in his own personal computer). Similarly, all output which is sent to the screen from a program should be capturable by a second program for interpretation and processing. This would allow a blind user to have a

program interpret the "video" output of another concurrently running program in order to feed him the "video" information in some other form.

SIMPLIFY SOFTWARE DESIGNED FOR USE IN PUBLIC PLACES

Software that appears in public places for use by a wide range of individuals can be made visually, linguistically, and cognitively simpler to increase its usability by a larger portion of the population.

HOW THESE ACCESS "MODIFICATIONS" INCREASE THE USEFULNESS (AND MARKET SIZE) FOR NON-DISABLED USERS (REGULAR MARKET OR MASS MARKET)

In addition to increasing the usability of computer systems by disabled individuals, the above modifications also provide greater access to and usability of computer systems by non-disabled individuals, who represent the bulk of the market for these computers. In fact, many new interface strategies for regular users can be identified from the work done in the disability area. Some of the ways in which these modifications benefit the market size or utility by regular users are:

KEYBOARD OPTIONS

This modification is not just for severely handicapped individuals. Any individual attempting to use the keyboard with one hand would find this useful. This includes not only individuals who have only one hand, but also individuals who have only one hand free.

ALTERNATE "KEYBOARD" ACCESS FEATURE

The availability of an alternate "keyboard" input point that was standardized would greatly facilitate the connection of keyboard alternatives of all types. This could include voice recognition keyboards, special environmental keyboards for use in hostile industrial environments or schools, eye-gaze keyboards, body-movement input systems, and large remote pointer keyboards such as might be used in group presentations or group use. The availability of a standard alternate input interface across computers would allow manufacturers to develop a single piece of hardware that could be easily used with most any computer or computer model on the market. It would also allow the use of specialty keyboards with all of the computers of a company (e.g., all IBM-PC family computers) even though their regular keyboards are incompatible. At the present time, a separate model is required for each computer and each model of computer in a line. For example, the Apple II and Apple IIe use different keyboards from each other, as do the IBM PC, the IBM PC-AT, and the IBM PCjr, making it difficult for both specialty manufacturers and the original manufacturers to create generally applicable specialty interfaces.

The existence of a keyboard emulating interface on a computer would also allow the computer to be more easily controlled by or fed with information from another computer.

ALTERNATE "SOURCE" CAPABILITY FOR ALL OTHER INPUT TECHNIQUES AS WELL (MOUSE, ETC.)

Again, this allows manufacturers to develop alternate approaches for different applications. For example, the special optical pointer and head-tilt mice that have been developed for disabled individuals might provide "hands-free" mouse operation for typists and other individuals who would like to have quick pointing capabilities on a screen, but who do not want to take their hands off the keyboard to operate a standard mouse. Currently, such alternate "hands-free mice" must be developed individually for each different computer or computer model.

ALTERNATE VIDEO SIGNAL ALWAYS AVAILABLE

The availability of a video connector allows users to use alternate displays, including large screen displays. It also allows the individual to record the images and mix them with other data or video signals when compatible.

AUDIO OR HEADPHONE SIGNAL AVAILABLE

Availability of headphone jacks allows the use of voice output software in noisy environments. It would also allow the use of talking software in environments where terminals are placed in close proximity, where it would otherwise be impossible to tell whose computer was talking to whose. Finally, it allows for simplified recording of speech, music, and other auditory information that might be generated by the computer programs.

EXTERNAL AVAILABILITY OF INFORMATION SENT TO SCREEN

As the VDI or similar communication standards for video information being sent from a program to the operating system are developed, it would seem highly advantageous to provide this information to some externally available output port for general market use. This information could then be fed to higher-resolution displays or printers, or used as a method for compressed transmission of the video image across data links. This may be especially valuable when using sophisticated graphics packages on portable computers having limited resolution displays. When an ordinary user is located at his workstation, he may wish to connect his low-resolution portable computer to a stationary system providing a larger and higher-resolution display.

VISUAL REDUNDANCY OF AUDITORY INFORMATION

Providing all auditory information in visual form would be useful both in high noise environments and in no-noise environments (libraries, etc.). This would be especially true in public access environments where headphones would be subject to theft or vandalism. It would also be true of situations where the user had to move around freely, or could not wear headphones for other reasons.

ALL INTER-PROGRAM DATA PATHS LEFT FULLY OPEN IN NEW OPERATING SYSTEMS AND ENVIRONMENTS

Provision of full keyboard data paths between programs would allow for more sophisticated systems in the future involving nesting programs. It also allows voice recognition software to be run in the same computer as the standard software and yet provide full access to the keyboard functions for the user without having to be computer hardware specific.

SIMPLIFY SOFTWARE DESIGNED FOR USE IN PUBLIC PLACES

Making public access software as simple to use as possible, both visually and conceptually, would increase its usability not only by individuals commonly categorized as "disabled," but also for elderly individuals, travellers, children, and bilingual individuals, as well as anyone who may be unfamiliar with automated information systems.

FUTURE POTENTIALS AND PROBLEMS

It is difficult to look far into the future. It is quite likely that computers and information systems will take on new forms and become so integrated into our society that it is not easy to imagine or discuss them in currently available terms and conceptual frameworks. A few trends in the near future, however, can be seen. These trends will provide even greater potential benefit to individuals with disabilities. Development of effective techniques to ensure open access to these systems by individuals with disabilities, however, promises to be challenging.

One clear advantage stems from the fact that, as more and more information is produced, transmitted, handled and used in electronic form, the current problems faced by individuals with physical and visual disabilities, involving the handling, production, and translation of the information into forms which they can use, have the potential to be greatly reduced. The ability of these individuals to affect the world around them, and to carry out many of their daily living activities (e.g., shopping) on a remote basis, could also be increased, thus releasing more time for them to be able to pursue interests and travel more related to productive or social activity than daily maintenance.

Some comments as to how the future may evolve, specifically in regard to computer access, are:

MOTOR IMPAIRED

As new interfaces are developed that are more precisely tuned to utilize all of a normal person's physical capabilities, we will find increasing problems faced by individuals who do not have full physical capabilities. As long as alternate, albeit slower, input access techniques are still supported, however, this will only be a hindrance, and not a barrier.

As systems get smaller and more integrated, we may find that some of the most advantageously small systems (especially for ambulatory individuals) may have few external input/output ports. Another problem that might arise in this regard is the development of integrated systems where a manufacturer designs the computer to work only with its own specially created peripherals. In some cases, this may be done to close out competition for peripherals. In other cases, it may be done simply to provide a lower-cost overall system by using simpler, lower-cost custom inter-unit communication formats. These could cause additional problems for disabled individuals if they are not considered.

On the positive side, we are also likely to see a number of alternate interfaces become available. As the diversity of these interfaces increases, so will the pressure for a standardized interface. In addition, the various interfaces themselves may be directly usable by individuals with disabilities. Voice input, for example, is one

technique that has already appeared, and which will be improving steadily in the future, and is quite valuable to individuals with some types of disabilities.

Another positive development is the expected separation of the programs and the input/output hardware. As programs rely more and more on operating systems for their input and output, the ability to provide alternate input and output mechanisms for disabled individuals which are compatible with standard software packages increases dramatically.

VISUALLY IMPAIRED

The greatest concern here is the rapid increase in the visual complexity of the displays. As display technology increases, it is expected that even greater use of more visually detailed displays will be made. In addition, relatively low-cost 3-dimensional displays have already been developed and are being used in industry. Providing a mechanism to handle this type of information for a blind individual will certainly be challenging. This will be especially true if 3-dimensional mice or "fingers" are developed to manipulate these images.

On the positive side, as discussed above, the separation of the program and its display drivers for current and future display mechanisms promises to make these tasks at least somewhat easier.

HEARING IMPAIRED

Voice output is the largest problem here. As long as information is provided in visual form as well, however, this should not be a serious problem.

Also, as voice recognition improves and comes down in cost over the next decade, deaf individuals may carry voice-to-text translators with them as a standard practice, for use in ordinary conversation.

OTHER NOTES

Of benefit to all types of disabled individuals will be the decreasing size of the systems, their increasing power, and their lower costs. As memory costs continue to plummet, even the smallest systems will have enough memory capability to handle more sophisticated operating systems, which can facilitate alternate access, multi-tasking, and program nesting. As long as alternate access points are provided in the architecture, the future for the disabled as it involves computers looks bright indeed. This includes both the use of the computers as special aids, and the increased access to the educational, work, and social environment components of our society by disabled individuals through standard computer systems.

A FINAL NOTE:

When working on implementing new computer access strategies, it is important to consult with someone who is familiar with the computer access problems of all of the disabled, to help ensure that an access strategy for one disability does not create access problems for other disabilities. For example, when curbcuts were originally installed, no thought was given to the ramifications for blind individuals. As a result, many blind individuals found themselves standing in the middle of the street in traffic, because they or their seeing eye dogs did not find the curb that they used as an indicator that they had come to the end of the sidewalk and the beginning of the treet. Different textures and specific contours are now provided with curbcuts to provide tactile indications of the curbcut for blind individuals.

In other cases, entire buildings have been made accessible -- except for one oversight which rendered the rest of the modifications moot.

In developing and implementing computer access strategies, we must take care to be as fully knowledgeable and informed as possible to avoid missing the one small but critical detail, and to prevent creating a barrier for one disability while trying to remove one for another.

ATTACHMENTS

ACCESS TO COMPUTERS BY ALL PEOPLE: THE NEED AND CONSTRAINTS

Comments prepared for the White House Planning Session on Computers and Handicapped Persons

February 24, 1984

Gregg C. Vanderheiden
Trace R&D Center, University of Wisconsin

THE NEED

Computers are becoming an integral part of our educational systems, most employment situations not involving manual labor, and even daily life--banking, shopping, etc.

As this occurs, the estimated 3-5 million people unable to physically use these systems will be at an extreme disadvantage. They may very likely be excluded from the regular education system and the work force. It is not economically feasible, nor in many cases even possible, to adapt the individual pieces or systems which will be encountered in the classroom or job site. There are too many pieces of software, changing too rapidly; and the software is often proprietary or specific to the company or application. Physically adapting the computers or modifying them one at a time to meet each person's individual disabilities is a similarly unworkable solution, especially when the individual is likely to run into a wide variety of computers. The one workable solution is to maintain the ability of individuals, regardless of the disability, to approach standard computers and operating systems as they are encountered, and be able to operate them and their software packages as they are found.

THE MANUFACTURER'S CONSTRAINTS

We recognize that manufacturers cannot afford to design their equipment to account for the very wide variety of users who may encounter the equipment. This does not apply just to the area of disabilities, but to all areas of computer use. The major computer hardware and software is targeted at the majority of the market, with smaller firms or specialty houses handling additions or modifications necessary for other applications. About the largest concession that can be expected in the mass market production and distribution of computers is to allow ports or access points in the architecture where special adaptations could be attached.

Beyond these minor, low-cost or no-cost considerations, it is usually not reasonable for a manufacturer to make large design changes for any small group, lest a manufacturer lose its competitive edge in this extremely competitive field.

Any solution strategy proposed should therefore involve very little or no incremental cost in the production and distribution of the individual computers,

operating systems, or software packages. Furthermore, it should not constrain the ability of computer and other information systems to grow and develop in widely diverse fashions.

POSSIBLE SOLUTION STRATEGIES

Since the "computer" as we know it is changing rapidly, as are both its input and output forms, no specific or describable solution strategies are going to be applicable either across all computer systems or for very long into the future.

As a starting point for discussion, the following guidelines are presented, followed by several examples of how these guidelines could have been applied at low or no cost in the computer systems that exist today. Please not that in many cases the adaptations increase the utility and function of the computer for all individuals (disabled or nondisabled) and therefore constitute enhancements of the computer and not just accommodations.

DESIGN GUIDELINES FOR MAXIMIZING COMPUTER ACCESS

1) Emphasis should be put on providing entry points, ports, or "hooks" onto which individuals requiring special input or output forms can attach their aids or software routines. These may be hardware or purely software hooks (see examples).

2) The philosophy is not to make the computers usable by all individuals with handicaps, but rather to provide the access points to which the individuals can attach software or hardware modules needed for their use of the systems.

3) Any modifications or accommodations to the hardware or operating system should be kept to an absolute minimum (unless the accommodation increases the utility of the system for all users).

4) Where possible, redundancy of input and output forms should be provided (e.g., keyboard access to mouse commands, text or visual parallel to voice output, audible feedback paired with visual output).

ILLUSTRATIONS

The attached illustrations show how the hardware or software operating systems of existing computers might be altered in simple and inexpensive ways in order to facilitate their use not only by individuals with disabilities but by other people as well.

ILLUSTRATION 1:

PEOPLE UNABLE TO USE A STANDARD KEYBOARD: PHYSICAL LIMITATIONS

PROBLEM

A large number of individuals are unable to use the standard keyboard on a computer due to a physical impairment. This impairment may be a spinal cord injury, brain stem infarct, or congenital physical disability. For these individuals, a number of aids or systems have been developed which can allow them to "type" by indicating the desired characters using specialized techniques. These techniques may involve only sipping and puffing on a tube, or the movement of the individual's eyes.

Unfortunately, it is not possible to use Visicalc, WordStar, or standard computer-aided instruction programs with these aids, since these programs and the computers on which they run accept input only from the computer keyboard. Thus, while the individuals can operate their own special rehabilitation aids, they are unable to use standard computers or computer software.

CURRENT SOLUTION STRATEGY (RETROFIT)

The solution that has been developed to solve this problem presently is to create a hardware module which exactly imitates the electrical signals of the keyboard. With this "keyboard emulator," the computer's existing keyboard is disconnected, and the emulator plugged in where the key is disconnected, and the emulator plugged in where the keyboard used to be connected. The keyboard emulator is set up to access standard RS232 serial ASCII, which the disabled individual's "special aid" is capable of sending. With this arrangement, the individual can "type" using a sip-and-puff switch, eye motions, or whatever is necessary, and have the selected characters fed to the computer exactly as if they were typed on the keyboard.

Since the emulator exactly mimics the signals of the keyboard, it is impossible for the computer or the software to tell the difference between the individual using the aid and someone using the standard keyboard on the computer. Because it is impossible for the computer to "see" this modification, this type of modification is termed "transparent." Because these techniques are fully transparent, the handicapped individual can run any standard software or use this computer in any way that any nondisabled person could control it from the keyboard. Any successful alternate input strategy must be transparent.

In order to allow the computer to also be used by nondisabled individuals, the keyboard emulators allow the original computer keyboard to be connected to them. The emulators then feed all keystrokes from the keyboard into the computer as well. As a result, installation of a keyboard emulator in a computer in now way alters the usability of the computer or of its operating characteristics to nondisabled users. In

fact, except for the extra connector on the back of the computer, it is impossible for a nondisabled user to tell that a keyboard emulator is installed in a computer. (For computers such as the IBM PC, which have separate keyboards, the emulator can simply be a box that is placed in line between the keyboard and the computer to provide a "Y" function, which feeds both the standard and special keyboard signals into the computer.)

THE PROBLEM WITH THIS SOLUTION

Although this adaptation provides totally transparent access to the computer, this approach has a number of shortcomings over the long haul. First, as each new computer is introduced, someone has to design a new keyboard emulator to mimic its signals. Even model changes (for example, the Apple II and the Apple IIe), if they change the keyboard electronics, require that a new keyboard emulator be designed. With the proliferation of computers, this problem is rapidly increasing.

Second, in many cases the computer purchased by a school system for use in classes, or which a company may use in its various departments, may not be one of the few standard computers for which keyboard emulators have been designed. In addition, a handicapped individual may have to use multiple computers for different activities on the job, or in different classrooms at school. This would require that a keyboard emulator be purchased and installed for each of the different computers. In addition, keyboard emulators are expensive, generally running $300 to $400.

A third problem is that many computers do not lend themselves well to keyboard emulators. Size and space considerations in the computer, as well as the tendency in smaller computers to integrate the keyboard into the main circuit, make installations of keyboard emulators difficult or impossible.

A BETTER SOLUTION BASED ON MODIFICATION OF THE OPERATING SYSTEM

Keyboard emulators themselves are examples of "retrofitted" solutions. A simpler approach would be to have had a "transfer keyboard" function built into the operating system initially. Although "transfer console" commands do exist in some operating systems, they are not sufficient, since they also transfer the display function at the same time. If a "transfer keyboard to a serial port" command were available on the computer, we would in fact have a built-in electronic "keyboard emulator" function provided at no cost. To handle the non-standard (non-ASCII) keys, special escape sequences or supra-ASCII codes (8-bit) could be used.

If this capability were built into operating systems and used in the software development, special keyboard emulator modules would not be required, and handicapped individuals could, with their own special interface aids, access standard computers and software.

ADVANTAGE OF THIS FEATURE TO THE GENERAL MARKET

In addition to providing access to individuals with disabilities, this function could also be of great utility for nondisabled individuals. One use of this feature would be the inputting of data to a program from a second computer. At the present time, an increasing number of individuals have both a stationary workstation computer and a portable lap computer. With this "transfer keyboard" function, individuals could prepare notes or work on their portable computer as they moved around, and, later, easily transfer the work to their other programs. By using the "transfer keyboard" command, the individuals could dump the contents of their portable computer into the serial port of the workstation computer and have the information "typed" directly into the particular application program desired. In the future, some transfer capabilities may be built into specific programs as special capabilities. If this capability already existed in the operating systems, however, it would be available today.

INCLUDING THESE CONSIDERATIONS IN FUTURE OPERATING SYSTEMS

Future operating systems promise to provide these types of capabilities, or capabilities which are very close to them. It would be unfortunate if these new capabilities were very close but not quite sufficient to meet this need.

Newer systems are also using new input modes such as the mouse. To enable disabled persons to use many of these systems, it will now be necessary to create "mouse emulators." One such "mouse emulator" is already under development, which will result in a totally hands-free mouse. Again, with some foresight in the design of the hardware and operating system which use mice, implementations of this technique could be facilitated, and its cost reduced. This type of approach would also have great advantage for nondisabled typists, providing them wit the quick editing capabilities of the mouse, but allowing them to keep both hands on the keys of the keyboard at the same time. It is quite conceivable to have a nondisabled person using a range of these techniques; for instance, using a rough pointing instrument such as a long-range lightpen attached to the head to do general text editing, a mouse to do finer movements when drawing, and keyboard cursor commands to move the cursor one pixel at a time to fine-tune the mouse. This would provide a wider variety of use for the nondisabled user, and more options for control for the disabled user.

ILLUSTRATION 2:

PEOPLE UNABLE TO USE A STANDARD CRT SCREEN: VISUAL IMPAIRMENTS

PROBLEM

Blind individuals are unable to see the screen of the computer monitor, and are therefore unable to use standard computer systems. Visually impaired individuals may have residual sight, but be unable to use the screens in their standard size or configuration. Special displays or aids are often available to assist with both of these problems. Unfortunately, taps or connections to the system to allow these individuals to access or use the information are generally not provided. Presented below is one possible aid for blind individuals which could provide them with access to most of the standard software. The design on one modern computer (the Macintosh), however, removed a connection normally available (the video signal) and thus inadvertently cut off this approach. Special adaptations can be added to the Macintosh to allow a video connector to be added to any particular unit. However, this does not address the problem of a blind or visually impaired individual walking up to an arbitrary Macintosh at school or the job site and trying to use it.

THE SOLUTION STRATEGY

One approach to providing access to visual display screens is a "Hapti-Vocal" CRT replacement. The technique draws its names from the term "haptic," referring to the sense of position of the hand, and "vocal" from its voice output.

In use, the blind individual has a small pad (similar to a pad of paper) lying on the table next to the computer. This pad essentially represents the CRT screen. When the individual touches the surface, the system responds by vocally telling the blind individual what is at that point of the screen. The system can provide the information to the blind individual letter by letter or word by word. The blind individual can cause the system to read the screen from that point on by simply touching two fingers to the tablet and spreading them. As he spreads his fingers, the system will begin reading at a rate proportionate to the distance between his two fingers. In this fashion, he can easily control the rate of reading, as well as back up and reread. A tone mode allows the individual to quickly scan the page with his fingers, identifying the layout in terms of columns and distinguishing between areas and numbers and areas of text. The system can also be instructed to direct the individual to the cursor position, or to multiple cursors, and to follow along, enunciating the information as the blind individual is typing at the keyboard. In its basic operating mode, the system does not handle graphics, but tonal modes can be used to assist the individual in "reading" some types of graphic information. In addition, extended intelligences in the

interface (see below) can allow for the interpretation and "reading" of many types of standard business graphics.

The new high resolution windowing software can also be handled by providing the system with the ability to handle various type fonts and through judicious placement of the windows by the blind individual.

How the Hapti-Vocal System Would Work

The hapti-vocal CRT interface would work by tapping the video signal put out by the computer and creating a bit-mapped image of the screen in the hapti-vocal adaptor's own memory. The unit would then perform character/form recognition on the screen. Because of the digital nature of the screen display, this would be a considerably easier task than optical character recognition of printed characters on paper (where a primary difficulty is the irregularity of the fonts and the data drop-out from broken characters). Computers with variable character fonts and even icons can be easily handled, since each shape can be given a name.

Since this CRT replacement would contain its own memory and intelligence, the extent of the graphics display which can be interpreted by the unit is open-ended. Through special electronics, the system can also handle different rastor frequencies to allow it to grab images from nonstandard terminals such as the IBM monochrome display and the Macintosh.

THE PROBLEM WITH THIS SOLUTION

This approach would essentially be usable with any system for which the video signal was accessible. The signal may be in any of several different forms, including composite video or separated synch format. For most computers, this is not a problem, as the monitors are either separate (allowing access to the signals), or a video connector is provided. On the Macintosh, however, the screen is built in, and no external video signals are currently available except on very specially configured versions (the Conrac Macs) which have composite video out (although there are plans for an external video signal on future Macintoshes).

ADVANTAGES OF THE FEATURE TO THE GENERAL MARKET

If a connector had been provided, or when one is provided, on the Macintosh (with any form of the video signals on it), it would not only enable access for the above technique (and for video expansion techniques for low vision) but would also have allowed the nondisabled users to connect alternate monitors, or to use special peripherals which require video signal processing.

One such peripheral would be a special hands-free mouse, which would allow individuals full use of the mouse capabilities of the Macintosh while leaving both hands on the home keys. This special mouse emulator could be used with any existing Macintosh and plugged in parallel with the existing mouse (so that both would be active). It would function in a completely transparent fashion, thus providing the

special hands-free mouse capability to any text processing applications where it was useful, in addition to allowing the use of the mouse for fine-grain graphics work. It would require no modifications of any kind to the operating system or the hardware of the Macintosh.

Unfortunately, the technique does require access to the video signal. Provision of the video signal for access for blind individuals would thus also have provided the signal necessary for this special high-speed text processing accessory for nondisabled individuals.

FUTURE SYSTEMS

This technique addresses the use of CRT-based systems. The ability to grab a screen image from non-CRT displays, however, will need to be addressed as newer display technologies receive wider application. Eventually, a very high resolution direct screen scanning optical system may be required.

ILLUSTRATION 3:

PEOPLE WITH HEARING LIMITATIONS UNABLE TO RESPOND TO SPECIAL ACOUSTIC SIGNALS

PROBLEM

At the present time, there are not serious problems to access to computers by individuals who are deaf. This could change if current trends toward speech output and elaborate tone signalling continue. At present, simple visual indicators which light up when a tone is emitted can be placed near the speakers of the computer to detect beeps or other sounds. As more sophisticated systems and programs using speech output are produced, however, this technique may not be sufficient for the full and effective use of such systems.

SOLUTION STRATEGY

The solution strategy would be simply to have any information which is presented auditorially be also presented visually, either concurrently or as an option.

ADVANTAGES OF THE FEATURE FOR THE GENERAL MARKET

First, a very large portion of our current population is hard of hearing, and would directly benefit from this option.

In addition, redundant presentation of auditory information has the potential of greatly increasing the effectiveness of communication for persons without hearing impairments as well as providing access. Computer terminals may often be operated in environments which are noisy enough that it is difficult to hear vocal output, or in environments where a computer which is constantly talking would be an annoyance. In both these cases, the ability to turn off the voice and have visual only, or a combination of auditory and visual, would be of benefit.

FINAL REMARKS

Not all of the needs of disabled individuals can be met with simple modifications or adaptations to the hardware and software. There will always be individuals and situations which require more extensive considerations. However, a very large portion of the problems currently faced by disabled individuals could be addressed with low- or no-cost changes. In addition, if those developing the software systems are aware of the types of problems faced, and the adaptations which would be of benefit, then an ever-increasing portion of these problems can be avoided completely. This is analogous to simply informing the people who are going to pour the curbs what curbcuts are and what their utility would be before they pour all of the curbs, rather than afterwards.

In addition, taking these problems into consideration can lead to a better design and more effective software, a more friendly interface, or a more flexible architecture. Curbcuts, for example, have benefited not only disabled individuals, but also people on bicycles, older persons with carts, parents with strollers, and delivery persons. Again, for instance, in National Airport there is one hall where one half of the hallway has 6 steps and the other is a ramp (both of equal width). The majority of the people walking down the hall use the ramp.

BOTTOM LINE

· Simple inexpensive considerations in the design of hardware and software can allow alternate access strategies to be effective for the 3-5 million people who have difficulty with standard I/O.

The only way to incorporate these considerations into the design of both hardware and software early, when they will be most effective, is through direct cooperation by the companies developing new computers and operating systems.

REPORT ON PROCEEDINGS
OCTOBER, 1985 MEETING

OF THE

GOVERNMENT/INDUSTRY INITIATIVE ON COMPUTER ACCESSIBILITY BY INDIVIDUALS WITH DISABILITIES

Co-chairpersons:

Lawrence Scadden, Ph.D.
Electronic Industries Foundation

Gregg C. Vanderheiden, Ph.D.
Trace R&D Center, Waisman Center
University of Wisconsin

REPORT ON PROCEEDINGS

INTRODUCTION

This was the second formal meeting of computer industry representatives on this project. The first meeting was at the White House on February 24, 1984. The objective of the first meeting was to familiarize the companies with the problem and to solicit their support for a cooperative effort to address the problem. The result of the first meeting was a recognition of the problem, and a request by the manufacturers for more information about the types of disabilities, the resulting barriers to the use of standard computers, and the types and scope of the solution strategies that the manufacturers were being asked to consider.

Subsequent to the meeting in February at the White House, briefings were held with manufacturers, and a White Paper was developed, distributed for comment, and revised and distributed in preparation for this second meeting (copy attached).

The second meeting (reported here) was held on October 24-25, 1985. It consisted of a one and one-half day work session followed by a reporting session at the Rayburn Building on Capitol Hill.

Computer firms represented included Apple, AT&T, Digital Equipment Corp, Hewlett Packard, Honeywell, IBM, and Tandy (Radio Shack).

ATTENDANCE

Attending the conference were:

Alan Brightman, Ph.D.	Apple Computer
Deane B. Blazie	Maryland Computer Services, Inc.
Frank Bowe, Ph.D.	Arch. & Transport. Barrier Compliance Board
Carl Brown	IBM
Albert Cavalier, Ph.D.	Association for Retarded Citizens
Frank Fitzgerald	Honeywell Corporation
Joan Forman	Digital Equipment Corporation
Richard Foulds, Ph.D.	Tufts New England Medical Center
Guy Hammer	Veterans Administration
David N. Henderson	Discovery Data Systems, Inc.
Alton Hodges, Ph.D.	OSERS-Department of Education
Charles Hunt	Honeywell Corporation
Neil Jacobson	Oakland, CA
Daniel Maday	General Services Administration
James McCormick	AT&T
Bob Mills	Electronic Industries Foundation
John Patterson, Ph.D.	Tandy Corporation
Arthur Rasmussen	Trace R&D Center-University of Wisconsin
Martha Redden, Ph.D.	Amer. Assoc. for the Advancement of Science
Barry Romich	Prentke Romich Company

Noel Runyan	Talking Tablet, Inc.
Lawrence Scadden, Ph.D.*	Electronic Industries Foundation
Joseph Shelton	Apple Computer, Inc.
Joseph Traub,	Natl. Inst. of Handicapped Research (DOE)
Gregg Vanderheiden, Ph.D.*	Trace R&D Center-University of Wisconsin
Bill Woods	Hewlett Packard Company

* co-chairmen

The purpose of this second meeting was to gather the now more thoroughly briefed industry, government, and research and disability representatives to define the problem both from the consumer and manufacturer points of view, and to develop strategies for further efforts in this area.

DISCUSSION TOPICS

Discussions during the day and a half session centered around:

- Problem identification
- Potential solution strategies for existing systems
- Constraints of manufacturers
- Practicality of different types of solution strategies
- Who within the manufacturers needs to be aware of the problems and the solution strategies
- Mechanisms for moving information to those individuals within the companies
- The form that this information should take
- The type of support that the manufacturers need from the field
- Development of a specific action plan with working groups

MAJOR POINTS FROM THE DISCUSSION

1. The primary objective is to impact the next generation of computers

Although the problems disabled people face with existing computers were used to highlight the problems faced by disabled persons, it was agreed by all that the primary impact of this committee would not be on the existing computers which were already in manufacture, but on the next and future generations of computers. It was not felt that this excluded support of adaptations to existing computers; however, the short lifetime of computers and the rapid pace of advancement indicated that the real efforts should be directed toward preventing the problems in future designs, rather than playing catch-up.

2. The focus of this group's work should be on future integration rather than retrofit adaptation.

The committee felt that the focus of the standard manufacturers' efforts should be on integration of access ideas into the mass market products, rather than developing adaptations to current or future products. The committee felt that adapting the

computer equipment was better left to the special rehabilitation manufacturers and was not an area in which the mass market manufacturers could be particularly effective, other than through cooperation. However, the incorporation of "hooks" or points within the standard computers' architecture where special adaptations could be connected was identified as a very important area for contribution by standard computer manufacturers. One specialty rehabilitation manufacturer said that their products could be brought out in one-fourth the time and at one-third the cost if connection points were provided or existing connection points were documented. It was also pointed out that these connection points would be of tremendous benefit to third-party software manufacturers for the non-disabled, mass market as well, and would solve many of the problems currently faced by that market.

3. The source of most barriers to disabled users is lack of knowledge by the design team.

From the discussion, it was clear that many of the barriers which exist were due simply to lack of awareness. Some manufacturer representatives reported that they would be recommending changes to pending designs immediately, based upon information presented at the meeting. The manufacturer representatives stressed the need to develop strategies for education of their industry.

4. The current architecture trend is in the right direction, but must be informed.

It was felt that the current direction in which both hardware and software design is headed is generally the correct direction for making computers more accessible to disabled persons. The need to ensure that the designers are aware of some of the current barriers faced by disabled persons, however, was seen as great, in order to prevent systems that are almost accessible *but....* An example might be a system that allowed input from any one of a number of input sources, except that the initial boot or reset procedure required that the individual operate the standard keyboard or depress several keys concurrently on the standard keyboard in order to start the process.

5. Open architecture is greatly beneficial to development of special personal aids for disabled persons, but does not solve the problem of general access to computers in the school, job and community.

Open architecture is of tremendous value in allowing computers to be used as building blocks in aids for disabled persons. The open architecture allows special adaptations and software to be developed for the computer to meet the special needs of disabled persons (e.g., a communication aid, a braille translator, etc.). The problem being addressed by this committee, however, is the ability of a disabled person to come up to any of the many computers that will be encountered in schools, jobs, and

communities in the near future, and to use any and all of these computers. Although this is not a pressing problem at the present time, since computers are only beginning to be integrated into these environments, it will not be long before it will be impossible to participate effectively in any of these environments unless the individual has the ability to use the computers and software as they are found, to do assignments, conduct experiments, carry out educational computer-based "experiences," take tests, complete questionnaires, access company data, conduct bank transactions, place orders, and even locate businesses or individuals in buildings with computer-based directories in their lobbies.

6. An "alternate access port" would solve many problems, but poses many problems in implementation.

If all computers and information processing systems had an "alternate access port" on them that was standard or semi-standard, disabled individuals would be able to easily connect their specialized input and display devices to them and use them. In addition, the non-disabled, mass market would also be able to use this port for connecting specialized keyboards, alternate data entry devices, and alternate displays. Problems in implementation exist, however. These include increased hardware cost unless the standard serial port is used; tying up the serial port if it is used; standardization of format within computer companies as well as across computer companies; cost concerns on small dedicated-function systems such as information or point-of-sale transaction; and environment considerations in outdoor placements.

7. The scope of the problem should be limited to computer systems for the present.

The committee felt that the discussion should initially focus just on microcomputers, and to some extent stand-alone computer terminals. It was felt that the microcomputers should be addressed first, and computer terminals being addressed second, before attempts were made to tackle issues such as automatic teller machines, dedicated information systems in shopping centers or building lobbies, computer controlled appliances and other applications where the part of the system with which the user interfaced did not resemble a microcomputer. It was felt that there was a continuum extending from microcomputers to microwave ovens and toasters, but that the committee would only focus on the top portion initially and spin off reports for terminals and design of other devices would follow at a later time.

8. The principal objective of this overall effort should be to inform and support key people within the manufacturing companies.

It was the unanimous opinion of the committee that the only mechanism for ensuring that the design of standard microcomputers would allow more widespread access by disabled persons was to make those people responsible for the design of the computers aware of the importance of specific design aspects and their impact on the usability of the computers by individuals having various types of disabilities. Thus the primary function of this effort should be to provide information and support to the key people responsible for the design. The principle audience of this effort should be

1) the design requirement people within the corporation.

2) the design engineers themselves.

3) the human factors designers.

4) the supervisors and management for the design team.

5) the corporate strategy personnel.

6) software design personnel.

7) operating system design development personnel.

It was felt that two types of documentation were required, one for top-level personnel to demonstrate need and establish the priority, and a second level necessary for those on the implementation level to make them aware of the specifics of the problems as well as of possible solution strategies.

9. Multiple strategies should be used in getting the information into the company.

It was felt that multiple media should be used, including both video and print materials. All materials should be kept short. Live presentations or short courses would be most useful for the companies. It was suggested that a subcommittee be formed to conduct presentations within the company. This group would come to the company, spend a couple of days with videotapes, live demonstrations and discussions with key personnel within the company, and then leave papers and guidelines with the company personnel. Other strategies for dissemination of the information discussed were:

- presentations at meetings that key corporation personnel normally attend, including IEEE meetings, EIA meetings, etc;

- articles within BYTE magazine could be used for general field awareness, and to reach individuals within the companies who may be interested but not contacted through other means;
- bulletin boards for sharing ideas as well as programs that demonstrate the problem may also be helpful.

In all of the above formats, it was felt that two-stage materials were the most useful, where Stage 1 consisted of a very short presentation of the key concepts and Stage 2 provided more in-depth discussion for those who wanted additional information.

<u>10. A set of guidelines should be developed and made available to designers within the companies.</u>

These guidelines should be developed as a group effort between manufacturers, researchers and consumers. The guidelines would include discussions of the disabilities, the problems faced as a result of specific computer features, potential future problem areas, ideas as to possible solution strategies, general guidelines, user requirements, and any standard approaches that may exist or already be in use for solving the problems. The following are some of the comments and recommendations that were made by committee members with regard to the development of the guidelines. Not all of these comments are completely consistent with each other.

- Recommendations should be specific.
- There should be a short list of guidelines with the rationale separated.
- The impact on the non-disabled, mass market should be included (both positive and negative impact if any).
- The problem should be described, not just a solution. Better solutions may be developed by the designers; also, if designers don't know the problem they may not solve it in implementing the proposed solution, may create the same problem someplace else, or may create a new problem in implementing the solution for an old problem.
- Designers can be an extremely valuable resource in developing solution strategies.
- Keep the guidelines short. If the guidelines are long, they won't be read.
- List only the most important recommendations; keep the list short.
- List everything, so that as many recommendations as possible can be implemented (also gives a better overall picture to the designers).
- Prioritize the problems and recommendations.
- Separate them by disability.
- Rank or rate their importance and impact.
- Separate the finished recommendations from any unsolved problems or initial ideas that may be in the write-ups.
- Cite similar problems faced by able-bodied users for each problem of disabled persons.
- Break into different categories by who it affects (e.g., the industrial design people, the operating system staff, etc.).

- Create two documents, one for top-level personnel and one for the implementation personnel.
- Create a videotape to go with the document to familiarize the designers with disabilities, the problems, and existing solution strategies.
- Aim at the human factors designer.
- Develop three levels of documentation: 1) the executive summary, 2) engineering documents, 3) documentation for technical support personnel (it would also be helpful for rehabilitation personnel to be available who can field questions of designers).
- Provide data to back up conclusions and priorities (market issue).
- Write recommendations in an easy, non-confrontational form (similar to the White Paper).
- Separate the design considerations from descriptions of special modifications that can be made to the computers post-manufacture.
- Be sure to point out what is in it for the manufacturers, including 1) mass market impact, 2) the disability market, 3) any multiplier effects, and 4) the public relations aspects.

Some of the discussion topics which were mentioned during the meeting as topics and examples that might be included in the Guidelines include:

POTENTIAL "GUIDELINE" DISCUSSION TOPIC AREAS

- Visual redundancy of auditory information for deaf and hearing impaired individuals.
- Open architecture -- its importance and uses by disabled persons.
- Design of hands-off interfaces.
- Alternate interface connection point on computers.
- Standard or well-documented keyboard interface.
- Simple or auto-loading disk drive.
- Copy protection -- implications for disabled individuals.
- One-finger operation modes for computers.
- Location and design of power and control switches and knobs.
- Size and visual contrast of letters on keys.
- Keyboard reassignability.
- Tactile nibs on home keys for visually impaired users.
- Access to video and auditory signals.
- Importance of additional serial port(s).
- Importance of detachable keyboard or auxiliary keyboard connection point.
- Importance of documented structure for memory resident programs.
- Connection point in operating system for routines to inject "keystrokes" and tap system output.
- Software design guidelines:
    - Hooks into the application software
    - Simple features in the software
    - Standard ways of doing things
        - Keys (second way when using mouse, etc.)
        - Flow control
- Guidelines for voice recognition options
- Alternate method for getting non-screen-based feedback (beeps and LEDs)

<u>11. Companies need access to rehabilitation experts.</u>

The manufacturers discussed problems they have had in securing good information from the rehabilitation community. The information is often distributed throughout the rehabilitation community without a good mechanism for tapping it. Opinions often differ and are contradictory. The manufacturers would like answers from people who are technically, clinically, and commercially knowledgeable and sensitive, so that options and trade-offs are more carefully thought through. A directory or reference/referral listing of resources and experts working in different areas would be useful.

<u>12. Rehabilitation developers need a mechanism to get technical information from companies.</u>

Rehabilitation developers expressed concern over difficulty in getting technical information from the companies. The difficulty results in greatly increased costs and time for development. Information is often available to private sector developers, but

not available to the rehabilitation community since they cannot demonstrate volume sales necessary to qualify within normal developer support relationships of the computer companies. The industry representatives acknowledged the potential for such a problem, and said that they would work toward a solution. They stressed that the solution would be quite different for each company. To facilitate the process, they asked that the type of information needed be identified. They suggested the possibility of developing a manual with particular information of interest to the disabled and rehabilitation community. Other ideas discussed included:

- setting up a mechanism to screen casual rehabilitation developers and have their questions handled by or through more informed rehabilitation research programs. This would reduce the number of repetitive requests made to the computer industry as well as reduce the number of casual developers who need more extensive technical training to be able to understand the documentation provided from the manufacturers.
- have companies identify commonly asked questions and get help from rehabilitation groups in developing answers.
- put commonly required information into the future standard technical reference manuals that are normally put out by the companies.

ACTION PLAN

The meeting resulted in four major actions. Each involved the development of a mechanism for carrying forward the activities initiated by the committee. They were:

1) A working group was established to identify, refine, and document ideas and guidelines for the design of standard computers to increase their accessibility by disabled and non-disabled people. A group was formed, a chairperson appointed, and the agenda for the group established. The initial working group will consist of (in alphabetical order):

Dean Blazie	David Henderson	James McCormick	Lawrence Scadden
Frank Bowe	Charles Hunt	John Patterson	Gregg Vanderheiden (chair)
Carl Brown	Neil Jacobson	Martha Redden	Bill Woods
Rick Foulds	Daniel Maday	Barry Romich	

The group will be open to any researchers, manufacturers, and consumers who want to work with the group. The objective of this cooperative industry-rehab group will be to develop materials for industry that can be used to improve the design of computers so that they will be usable by a larger portion of the population. The primary focus of the committee will be on the development of the design guidelines. These will include information regarding the disabilities and their impact, the specific problems currently encountered, future anticipated problem areas, and existing or suggested design strategies as they are identified. This effort will be coordinated out of the Trace R&D Center at the University of Wisconsin-Madison.

2) Mechanisms were established for moving this information to the designers and design decision makers within the computer manufacturers. It was emphasized by the industry participants that these mechanisms would be quite different for each computer company. No uniform mechanism will be established, therefore across companies. Rather, the individual industry participants committed to working within their companies in developing and coordinating these mechanisms. The first exercise of these mechanisms will be in conjunction with the review and refinement of the "guidelines" documents from Activity 1.

3) A group was named to set up a system for companies to be able to access information from the rehabilitation community. Dr. Martha Redden from the program on the Handicapped in Science of the AAAS will head a group that includes Joan Forman, DEC; Dr. Lawrence Scadden, EIF; and Dr. Gregg Vanderheiden, Trace. This group will develop a resource list and mechanism for identifying individuals within the rehabilitation community who can act as resources to the computer industry in various areas.

4) The establishment of mechanisms for rehabilitation developers to more easily access technical information from the computer industry. Each of the participating manufacturers will be identifying a key person within their companies to act as the contact point for requests of this type. Initially the members of the committee will serve in this capacity. Members will also be exploring mechanisms within their companies to make it easier for rehabilitation developers and manufacturers to secure needed technical information.

For further information, contact:

Dr. Lawrence Scadden
Electronic Industries Foundation
1901 Pennsylvania Avenue NW
Suite 700
Washington, DC 20006
(general information)

Dr. Gregg Vanderheiden
Trace R&D Center
University of Wisconsin-Madison
1500 Highland Avenue
Madison, WI 53705
(general information, the guidelines subcommittee)